

- Do not install multiple smaller pipes at a site instead of a larger pipe. It is not a workable alternative, as smaller pipes are much more likely to be plugged.
- Utilize other management options, as needed in situations where beaver have a history of plugging even large culverts (see section 5.4.4.1).

## 5.4 Wildlife Management

### 5.4.1 *Assessment of Impacts of Planned Watershed Management Activities*

The management activities described in this plan will have various impacts on the wildlife community at Quabbin. Most impacts on the wildlife community will be a result of habitat changes or modifications. The forest management approach described in this plan has landscape level affects, although individual changes at any given time will be very localized and small. While the management techniques used to reach the forest management goals will not be as dramatic as historic events (1938 hurricane, flooding of the reservoir), it is important to understand how these plans will affect the habitat and wildlife communities on the watershed.

The Division's primary long-term forest management goal is to establish and/or maintain a forest cover of diverse native tree species of many different age classes on a majority of its land holdings. This goal will primarily be accomplished through uneven-aged forest management. A 20-30 year cutting cycle will be used in most areas, and harvest will be through selection of individual trees or small groups (1/20-1/4 up to 2 acres). Uneven-aged management is the best technique for preserving individual trees of high wildlife value (dens, nests, roost, mast producers) (Payne and Bryant 1994). In addition, uneven-aged management increases vertical diversity. The end result is an even distribution of a low but constant population of understory plants and associated wildlife (Payne and Bryant 1994).

Meeting this primary objective will mean wildlife communities on Division land will be dominated by species adapted to forest conditions. Those species requiring early successional or open habitat will be less common and isolated to those areas where that type of habitat exists. Open and early successional habitat will be maintained on a small percentage of the Division's land, primarily associated with developed areas (dams, dikes), beaver impoundments, and existing fields. Forest wildlife communities should benefit the most from the Division's management plan.

### 5.4.2 *Active Management to Enhance Habitat for Selected Wildlife Species*

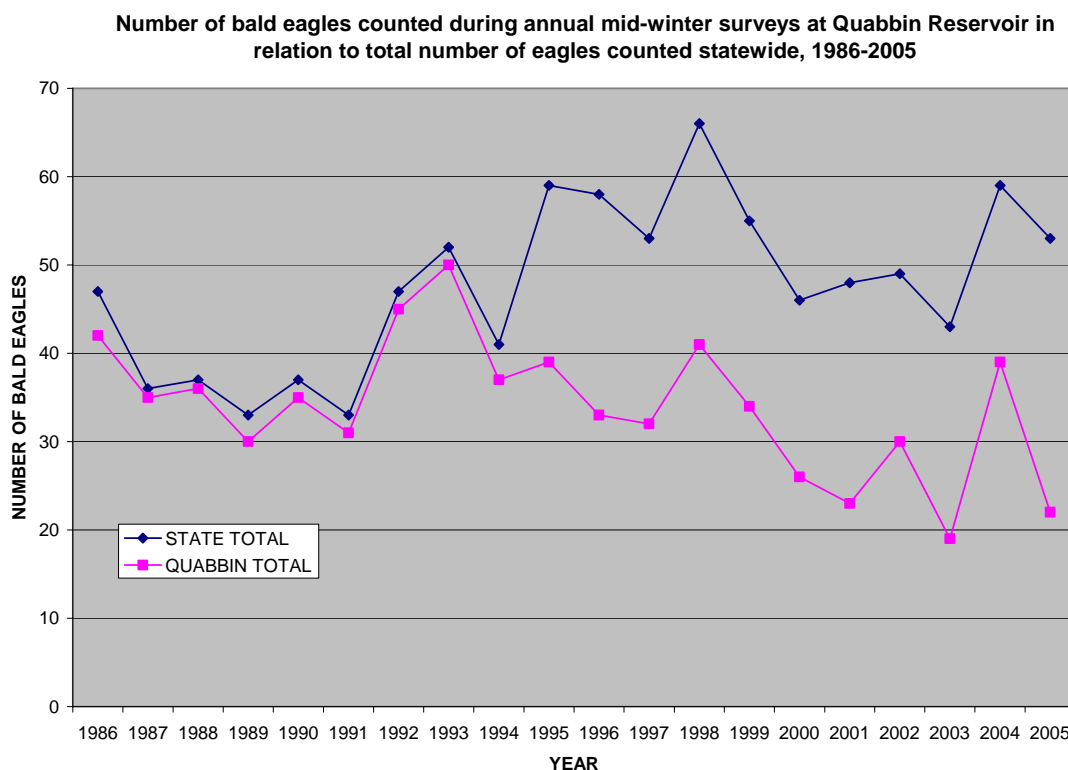
#### 5.4.2.1 **Bald Eagles**

Quabbin Reservoir has played a critical role in the recovery and continued success of bald eagles in Massachusetts. From 1982 to 1988, 41 bald eagle chicks from Michigan and Canada were transported to Quabbin Reservoir and "hacked" or raised in artificial nesting platforms without human association. The efforts paid off in 1989 when 2 pairs at Quabbin produced the state's first successful breeding efforts. Eagles have bred successfully at Quabbin each year since, and anywhere from 3-5 pairs may breed annually.

Quabbin also serves as a vital wintering area for both resident and non-resident bald eagles. Because of its large size, Quabbin is often the last body of water in the state to freeze, providing open water habitat for eagles well into the winter. Annual mid-winter eagle counts have been conducted in Massachusetts since 1986 along 2 standardized routes (Quabbin Reservoir and Assawompsett Pond). Two additional routes (Connecticut River and Merrimack River) were added in 1995. In the last 20 years, Quabbin reservoir has consistently attracted more wintering eagles than any other area in the state. In fact, the

eagle count at Quabbin has accounted for 41-97% of the total number of eagles seen during the annual survey (**Figure 19**).

**Figure 19: Mid-Winter Bald Eagle Counts at Quabbin Reservoir and Statewide, 1986-2005**



The bald eagle continues to recover on a national level. In 1995, the Federal status of the bald eagle was changed from Endangered to Threatened. In June of 2007, the Federal government removed the bald eagle from the endangered species list. It still has federal protection through the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. Its status in Massachusetts remains endangered. As a result, continued effort is made by the Division to ensure its existence at Quabbin. In cooperation with MassWildlife, buoys are placed in the water near active eagle nests to exclude fishermen and boaters from approaching too close. Each spring active nests are visited and eagle chicks are leg-banded, blood is drawn, and overall health is recorded. Leg bands provide critical survival, dispersal, and breeding information.

Finally, special attention is given to shoreline nesting and roosting habitat. When forestry operations are conducted along the reservoir's shoreline, super-canopy trees are selectively saved because these are favored by nesting eagles. In addition, other high quality potential nest trees, particularly hardwood trees with 3-pronged forks or conifer trees with a "bowl" shape near the top are saved. Lastly, consideration is given to thinning around these quality trees to ensure continued growth and allow for easy flight paths in and out of the tree.

#### **5.4.2.2 Common Loons**

There is little evidence of nesting loons in Massachusetts during the first half of the 20<sup>th</sup> century. Between 1940 and 1970 there are sporadic reports of nesting at Quabbin including one report in 1943 and another in 1959. Since 1975, loons have nested annually at Quabbin. Currently, Quabbin hosts the

largest number of breeding pairs of any water body in the state. During the 2005 nesting season, 13 pairs were present on the reservoir; 6 pairs nested, and they produced 10 chicks.

Loons prefer to nest on islands with sandy shores, low-lying vegetation, and a shallow approach that makes it easier to travel to and from the nest. Most loon territories on Quabbin have at least one potential nesting island. However, because Quabbin is a water supply reservoir, its water levels can fluctuate greatly depending on precipitation and consumer use. While loons can tolerate some fluctuation in water levels, increases of more than 6 inches or drops of more than 12 inches typically mean nest flooding or abandonment, respectively. Reservoir water levels cannot be specifically controlled during the loon nesting season. Therefore, in order to overcome potential water level problems, the Division utilizes artificial nesting rafts.



Artificial loon nesting raft

These loon rafts are constructed of dried cedar logs, wire mesh, and a camouflage canopy. Rafts are loaded with vegetation and anchored in the loon's territory each spring. During late summer, rafts are towed to shore, propped up, and stored for the winter. At Quabbin, there are currently 11 rafts in 11 different loon territories. Rafts allow nesting loons to escape fluctuating water levels. While rafts can increase loon productivity, they do not always succeed in attracting the nesting pair. There are several loon pairs at Quabbin that have a raft in their territory that still chose to nest on a natural island.

#### **5.4.2.3 Nest Boxes for Land Birds**

Some bird species may lack suitable nesting sites needed for successful breeding. While nest boxes are not a substitute for proper habitat management that provides natural snags and cavity trees, they can provide rare or uncommon species an opportunity to increase its local or regional population. As many as 50 species of North American birds are known to use nest boxes (Payne and Bryant 1994). In particular, bluebirds, kestrels, and a variety of owls respond well to the presence of nest boxes.

There are approximately 20 nest boxes located in early successional non-forested habitat on Quabbin Reservation. The boxes were originally erected to attract breeding bluebirds to the open habitats. However, many boxes need repair or to be replaced. In addition, little effort is made to adequately remove old nesting material, inspect the boxes during nesting season to remove unwanted species, or checked for insect infestations. Efforts will be made to inventory existing boxes, make necessary repairs, and monitor nesting effort during the season. In addition, other nesting boxes may be erected to attract kestrels and/or owls.

#### **5.4.2.4 Snake Hibernacula**

There is one known snake hibernaculum on the Reservation located in Hardwick in an old spoil pile that was created when one of the vertical shafts was dug. The spoil pile is essentially a huge mound of rocks and stones that provides small cavities and crevices where snakes can spend the winter. Snakes make their way through the crevices to areas below the frost line. Ideally, hibernacula face south to allow adequate sun exposure. Over time, these spoil piles grow vegetation, including large trees. The vegetation, particularly large conifer trees, can create too much shade and degrade the quality of the site. In order to restore the full potential of the hibernaculum in Hardwick, the Division removed all vegetation from the spoil pile to allow full sunlight to reach the ground. This vegetation removal will be conducted periodically to maintain the habitat.

### **5.4.3 Conservation Management Practices (CMPs) for Wildlife Management**

DWSP foresters are concerned primarily about maintaining water quality standards and improving forest health and vigor. Monetary gain from forest resources is a minor consideration when planning management activities. A direct result of this flexibility is that it allows DWSP foresters to incorporate sound and beneficial wildlife management components into their forest cutting plans. High quality mast trees, active and potential den and nest trees, and critical habitats have been, and continue to be, conserved and encouraged on DWSP property.

CMPs for wildlife management are generally complementary to water quality protection standards. The following wildlife CMPs highlight current management techniques already being practiced and elaborate on other management techniques that can be employed.

#### **5.4.3.1 Habitat Features and Management Recommendations**

##### **5.4.3.1.1 Vernal Pools**

**Management Objective:** DWSP will locate and identify all vernal pools on its properties and maintain vernal pool depressions in an undisturbed state.

##### **Recommended Practices - General:**

- Seek additional input from NHESP when management activities are going to occur around a pool that contains state-listed species.
- Digitize all aerially interpreted vernal pools and provide data layer to GIS personnel for inclusion in land management activity plans.
- Identify and confirm status of photo-interpreted vernal pools.

##### **Recommended Practices within Pool Depression:**

- Continue to maintain physical integrity of pool depression and its ability to seasonally hold water.
- Continue to keep depression free of slash, treetops, and sediment from forestry operations. If slash does fall into pool during the breeding season do not remove it so breeding activity is not disturbed.

##### **Recommended Practices at Edge of Pool:**

- Keep shaded condition in 100-foot buffer zone around pool depression.
- Minimize disturbance of forest floor within 200 feet of pool edge.
- Avoid making ruts >6 inches deep within 200 feet of the pool.
- Conduct low-intensity harvests preferably when ground is frozen.

Vernal pools are contained basin depressions with no permanent outlet that typically hold water for at least 2-3 months in the spring and summer. Vernal pools may or may not dry completely each year, but their periodic drying, shallow water, winter freezing, and low oxygen levels keeps them free of fish populations.

Because of their unique characteristics, vernal pools play a critical role in the life cycles of many amphibians, reptiles, and invertebrates. As a result, the Division considers vernal pools to be critical wildlife habitats. In fact, many state-listed species are associated with, or dependent on, vernal pools. Many vernal pools dry completely during the late summer and fall and can be difficult to identify. In recent years, the Division has made efforts to locate and identify vernal pools during the spring. Accurate and detailed records of located pools, including UTM coordinates and animal use, are stored in databases. In addition, the University of Massachusetts, Amherst



Vernal pool

identified over 500 “potential” vernal pools on the Quabbin watershed through aerial photos. These pool locations have been digitized; field checking to ascertain their status is part of the on-going spring field work. Locations of documented vernal pools will be transferred to a GIS datalayer for inclusion in land management planning documents.

Research is currently being conducted at Quabbin Reservation to test the effectiveness of Massachusetts Best Management Practices for vernal pools. While the state BMPs provide direct protection of the pool, there is concern that the wildlife species utilizing the pool may also rely on a larger area surrounding the pool for a majority of their life cycle. This research will test the effectiveness of the current BMPs.

#### 5.4.3.1.2 Seeps

**Management Objective:** DWSP will continue to protect seeps, springs, and surrounding soils.

##### **Recommended Practices:**

- Avoid leaving slash in woodland seeps or springs.
- Maintain mast-producing trees above and around seep.
- Remove conifer trees on south side of seep; retain conifers on north and west sides of seep.
- Schedule harvests to occur on frozen ground or during the driest conditions where seeps are present.
- Avoid running heavy equipment within 50 feet of the edge of a seep.
- Use seeps, when feasible, as the center for uncut patches to retain cavity trees, snags, and other wildlife features.
- Lay out skid trails and roads in stands where seeps are present and obvious prior to the harvest.



Winter seep

Woodland seeps tend to be small ( $< \frac{1}{4}$  acre) areas where ground water flows to the surface of the forest floor and saturates the soil. Seeps generally don't freeze during the winter and typically have little or no snow cover. Seeps often occur in natural depressions and may act as “seed traps” in which nuts, seeds, and fruits from surrounding trees and shrubs accumulate. This makes

them important winter feeding sites for turkey, deer, and other wildlife.

Seeps provide a seasonally important source of food and water for resident and migratory wildlife (Hobson et al., 1993). These areas tend to have early sources of green vegetation. This can be an important food source for black bears in the spring and early summer. Earthworms and insects at seeps attract early migrants such as robins and woodcock. Spring salamanders and hibernating frogs, which can attract skunks and raccoons, may also use seeps.

#### **5.4.3.1.3 Orchards and Fruit Trees**

**Management Objective:** DWSP will save apple and other fruit trees and increase their health and vigor when feasible.

**Recommended Practices:**

- Continue to identify abandoned orchards and clusters of fruit trees.
- When trees are being marked for harvest, save, if possible, all fruit trees.
- Remove other trees and shrubs, when feasible, back to the drip line of the apple tree.
- Remove large over-topping trees if the fruit tree is shaded by them on at least 3 sides, particularly to the south.
- Prune and fertilize trees, when possible, at least every 3 years.

Abandoned apple orchards and scattered fruit trees exist on DWSP watershed property. Wild apple trees are one of the most valuable wildlife food species in the Northeast (Elliot 1998, Tubbs et al., 1987, Hobson et al., 1993). White-tailed deer, grouse, squirrels, fox, fisher, porcupine, and rabbits will eat apples or apple seeds. Apple trees also provide nesting and perching habitat for bluebirds, flycatchers, robins, orioles, and sapsuckers (Elliot 1998). Apple trees in abandoned orchards eventually become crowded by invading shrubs and over-topped by the encroaching forest. Prolonged crowding and shading will lead to decreased vigor and eventually death.



Young apples

#### **5.4.3.1.4 Wildlife Wintering Areas**

**Management Objective:** DWSP will maintain the functional value of wildlife wintering areas.

**Recommended Practices:**

- Identify and map all known or potential WWA using aerial photos, cover type maps, and field inspections.
- Schedule forest harvest operations within WWA, when feasible, during December-April so tree tops are available for browse.
- Protect advanced conifer regeneration during timber harvesting.
- Cut stumps low to encourage vigorous sprouting.
- Planned activities within WWA should be conducted to ensure that at least 50% of the wintering area remains in closed canopy coniferous overstory to provide functional shelter.
- Avoid concentrating harvest in any one area of the WWA.

- Try and maintain travel corridors (unbroken, dense softwood cover 60-100m wide) that connect all areas of the WWA.

Wildlife wintering areas (WWA) provide shelter and food for animals during the winter months when cold temperatures, snow cover, and limited food resources create physiologically demanding conditions. An important wintering area is often related to white-tailed deer use of concentration areas or “yards.” These deer wintering areas (DWA) typically are in hemlock or pine stands where there is >70 percent conifer crown closure (Elliot 1998). Deer typically move to these areas when snow depths are around 12” (Flatebo et al., 1999). DWA provide reduced snow depths, higher nighttime temperatures, reduced wind, and greater relative humidity (Flatebo et al., 1999).

These areas must not only provide adequate cover, but also a quality supply of deer food. Cedar, red and sugar maple, birch, and hemlock are preferred foods. Another important wintering area is dense conifer cover (e.g., spruce stands) that provides increased thermal protection and wind cover for a variety of birds and mammals. For example, grouse will seek conifer stands when snow depths are <8 inches for thermal protection.

The general guideline for wildlife wintering areas is to maintain as much overstory as possible, while providing for the establishment and continued growth of preferred browse and conifer tree species.



Wildlife wintering areas

#### 5.4.3.1.5 Mast

**Management Objective:** DWSP will continue to maintain and encourage a variety of mast-producing plants within the watershed.

#### **Recommended Practices:**

- Continue to manage stands to contain multiple species of mast-producing trees and shrubs.
- Continue to retain productive beech, oak, and hickory trees when they occur as single or scattered trees in stands dominated by other species.
- Retain beech trees with smooth or blocky bark or raised lesions to promote resistance; remove standing trees with sunken cankers or dead patches to reduce sprouting of diseased individuals. Retain some large beech trees that have potential for good mast production, regardless of disease condition.
- Lay out skid trails and roads that avoid vigorous patches of understory shrubs.
- Save all hardwood mast trees that occur in conifer plantations when practical.

Mast is a critical component of quality wildlife habitat. Trees, shrubs, and vines produce fruits, nuts, and berries called mast. Mast can be hard (nuts, seeds) or soft (fruit, berries). It contains more fat and protein than other plant foods and is actively sought by a variety of birds and mammals. In autumn, mast is particularly important as many animals will focus on eating mast in preparation for winter. Bears, squirrels, raccoons, deer, and turkey will fatten up on acorns, beechnuts, and hickory nuts. Resident songbirds such as nuthatches, chickadees, and bluejays rely on mast during winter when other food is scarce. Migrating birds will often rely on fruits and berries during migratory stops to replenish energy.

Although all trees and shrubs are defined as mast producers, some species are more important to wildlife. The value of mast to wildlife differs with the size, palatability, accessibility, nutritional content, abundance, and production frequency (Flatebo et al., 1999). In general, oak, hickory, beech, walnut, butternut, cherry, ash, and conifers are the most important mast trees. In addition, birch, hazel, alder, and aspen are also important to some wildlife species.

#### 5.4.3.1.5.1 *Hard Mast*

At the Quabbin, red, white, black, and scarlet oaks are the most important source of mast. Hickories and beech comprise a relatively (< 3%) small component of the overstory. Oaks are probably the most important wildlife mast trees in the northeast. Acorns are eaten by over 100 species of birds and mammals (Healy 1997a). The frequency and characteristics of oak production varies from species to species. Red oaks produce a good crop of acorns every 2-5 years, black oaks every 2-3 years, and white oaks every 4-10 years. Red and black oak acorns take 2 years to develop, while white oaks take only 1 year. Peak acorn production begins at around 25 years for red oaks, 40 years for white oaks, and 40-75 years for black oaks (Flatebo et al., 1999). White oak acorns contain less tannin and may be more palatable to wildlife.

Beech and hickory trees comprise a small component of the Quabbin watershed forest. Hickories are scattered around the watershed and can be locally abundant in some compartments. They are also found along interior roads near former home sites. They have good seed crops every 1-3 years and begin producing quality crops at 40 years. Hickory nuts have one of the highest fat contents of any mast. Beech trees are extremely rare within the watershed, comprising less than 0.5% of the overstory. The prevalence of beech bark disease and low market demand has shifted attention away from this species. However, beechnuts can be an important source of food for a variety of wildlife. Wild turkeys prefer beechnuts to all other mast (Williamson, undated).

The seeds of maples, birches, ashes, and conifers provide food for many birds and small mammals. Red squirrels rely heavily on conifer seeds and their populations will fluctuate in response to annual crops. Birches are an important mast producer because most of the seed crop is retained on the tree above the snow. Birds, including pine siskins and grouse, count on birch seeds for their winter diet. White and red pines are the most widely distributed conifers at Quabbin. Mice, voles, grosbeaks, and finches are a few of the animals that utilize conifer mast. Chickadees and goldfinches prefer hemlock seeds.



Grapes, an example of soft mast

#### 5.4.3.1.5.2 *Soft Mast*

Black cherry trees comprise a relatively small percentage of the Quabbin watershed forest canopy. However, bears, small mammals, and over 20 bird species eat cherries (Flatebo et al., 1999). Pin and chokecherries are short-lived, but provide valuable fruit to wildlife. A variety of understory shrubs and

trees produce soft mast. Blueberries, serviceberries, dogwoods, and viburnums are abundant. In addition, herbaceous plants such as blackberry, raspberry, wild strawberry, and partridgeberry, are utilized by many species of wildlife, as are grapes.

#### 5.4.3.1.6 *Wildlife Trees*

Wildlife trees are often divided into two categories: snags and den trees. Snags are standing dead or partially dead trees at least 6" dbh and 20 feet in height. Den trees are live trees possessing a cavity large enough to serve as shelter for birds and mammals or a site to give birth and raise young. In general, den trees must be 15" or greater in dbh and have a minimum cavity opening of 4" in diameter (Blodgett 1985). Over 50 species of northeastern birds and mammals utilize snag and den trees during part of their lives (Blodgett 1985). Some uses of snags and den trees include cavity nest sites, nesting platforms, food cache, dwellings or dens, nesting under bark, overwintering sites, hunting and hawking perches, sources of feeding substrate, and roosting.

Forestry operations most likely have the greatest potential impact on the number, type, and location of snag and den trees at Quabbin. Thinnings, salvage, firewood cutting, and windthrow will result in wildlife tree loss. The Division's use of uneven-aged management, however, is conducive to snag management. Single-tree or group selection harvest practices will have only slight to moderate adverse impacts on snag production and retention. Although it would be ideal to salvage all wildlife trees, practical field applications make that unlikely. It is possible to maintain an optimal number of snags and dens across the watershed (**Table 53**).

**Table 53: Optimum Number of Snags/Den Trees per 100 Acres by Habitat Type**

<b>Tree dbh (in)</b>	<b>Forest Interior</b>		<b>Semiopen/ open</b>	<b>Wooded Watercourse</b>
	<i>Dens</i>	<i>Snags</i>	<i>Dens<sup>1</sup></i>	<i>Dens<sup>1</sup></i>
> 19	100	0	300	200
10-19	400	400	400	1400
< 10	200	200	300	900

<sup>1</sup> Animals here need den trees because creating snags by deadening trees is not recommended in these land-use types.

Source: Payne and Bryant, 1994

##### 5.4.3.1.6.1 *Snags*

**Management Objectives:** Forestry operations will continue to provide a supply of good to excellent quality snag trees, distributed over time and space in order to maintain self-sustaining populations of all cavity dependent wildlife. In areas where good snag trees are lacking, poorer quality trees should be retained until better trees develop.

#### **Recommended Practices:**

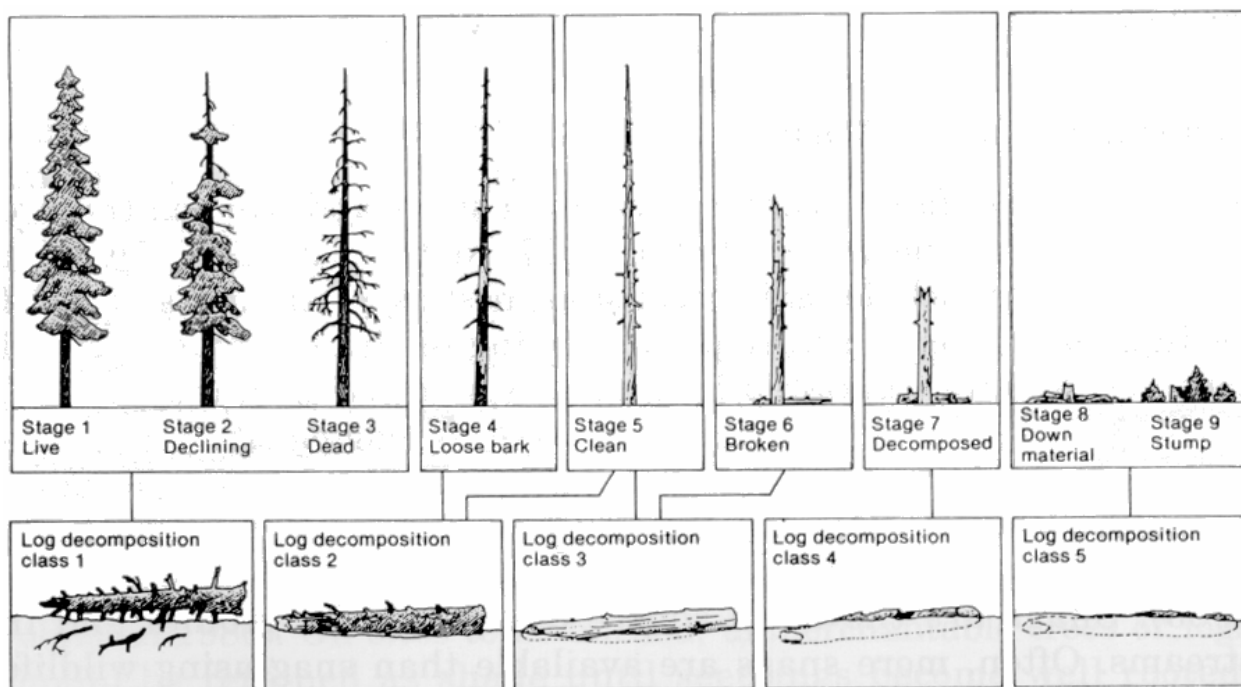
- Leave all snags when possible, within 100 feet of wetlands and riparian areas.
- Maintain a minimum of 6 snag trees per acre; 4 should be > 24" dbh and 2 <24" dbh.
- Avoid disturbing snags from April to July to stay away from nesting birds and denning mammals.
- Leave snags in place as coarse woody debris instead of removing them if they are felled during management operations.
- Identify, when possible, current or potential snags through exterior signs such as fungal conks, butt rot, burls, cracks, wounds/scars from lightning, fire, or mechanical damage, woodpecker holes or cavities, or dead or broken limbs or tops so they can be retained.

As a tree dies, it progresses through several stages of decay (**Figure 20**) and is used by different wildlife at each stage. Newly exposed bare branches provide excellent perches for woodland hawks (Cooper's, sharp shinned), as well as flycatchers and phoebes. During the loose bark stage, brown creepers and bats may nest or roost under the bark.

As a tree deteriorates, primary excavators (woodpeckers) begin to create cavities. Almost all northeastern woodpeckers excavate nest cavities in live or dead trees. Secondary nesters then use these cavities. Once trees have decayed to a point where there are no longer branches, it is classified as a snag (< 20 feet tall is a stub). Many insectivorous birds will use the snag for foraging. Finally the snag will either topple to the ground or wear to a stump. The fallen log provides habitat for carpenter ants. In addition, amphibians and reptiles will live in and under the rotting wood; small mammals also utilize the downed logs.

In addition to the stages of decay, other variables determine a particular snag's value to specific wildlife species. Characteristics such as tree size, location, species, and how it was killed are important determinants of wildlife use (DeGraaf and Shigo 1985). In general, when managing for cavity trees, the rule "bigger is better" applies. Large birds need large diameter trees to excavate nesting cavities. Smaller birds are able to find nest sites in large trees, but it does not work the other way. In addition, large snags usually stand longer than smaller ones. Emphasis is often placed on managing for viable woodpecker populations because their success will provide enough nesting sites for secondary cavity nesters. **Table 54** gives the number of cavity trees necessary to sustain the hypothetical maximum populations of nine woodpecker species found in New England.

**Figure 20: Decomposition of Snags and Coarse Woody Debris**



**Table 54: Number of Cavity Trees Needed to Sustain New England Woodpecker Populations**

Species	Territory Size (Acres)	Avg. Nest Tree <sup>1</sup>		(A) Cavity Trees Used, Minimum (N)	(B) Pairs/100 acres, Maximum (N)	(C) Cavity Trees Needed/100 acres <sup>2</sup> (AxB) (N)
		DBH (in.)	Height (ft.)			
Red-Headed Woodpecker	10	20	40	2	10	20
Red-bellied Woodpecker	15	18	40	4	6.3	25
Yellow-bellied Sapsucker	10	12	30	1	10	10
Downy Woodpecker	10	8	20	4	10	40
Hairy Woodpecker	20	12	30	4	5	20
Three-toed Woodpecker	75	14	30	4	1.3	5
Black-backed Woodpecker	75	15	30	4	1.3	5
Northern Flicker	40	15	30	2	2.5	5
Pileated Woodpecker	175	22	60	4	0.6	2.4

Source: DeGraaf and Shigo, 1985.

<sup>1</sup> Larger trees may be substituted for smaller trees. <sup>2</sup> Number of cavity trees needed to sustain population at hypothetical maximum level.

#### 5.4.3.1.6.2 Den Trees

**Management Objective:** DWSP will provide a continuing supply of good to excellent quality den trees, distributed over time and space in order to maintain self-sustaining populations of all cavity dependent wildlife. In areas where good den trees are lacking, poorer quality trees will be retained until better trees develop.

#### Recommended Practices:

- Retain as many live trees with existing cavities and large unmarketable trees as possible.
- When possible, retain all trees > 29" dbh or at a minimum 2 or more trees >29" dbh per 100 acres.
- Leave at least 1 tree 15-29" dbh per acre.
- Leave at least 1 tree per acre that shows potential for developing into a den tree (broken top, large broken limbs, fire scar); oaks, sugar maples, ash, and hemlock are good trees to select because they readily form natural cavities or are long-lived.
- Leave all den trees within 100 feet of a wetland or riparian area.



Den tree

Den trees are living, hollow trees used by a variety of mammals including mice, raccoons, squirrels, and bears. In general, there are usually fewer den trees available in an area than could be used by wildlife because large (>15" dbh) rough or rotten trees are relatively rare.

Unlike cavity trees, which have central columns of decay, den trees are hollow or have large hollow limbs, but are still alive and vigorous. Den trees usually have easily visible openings in the sound wood. Some heavily used den trees (e.g., by raccoons) are hardwoods with the top snapped off. Den trees usually have low commercial value, but their value to wildlife is extremely high and long lasting. It may take 100 years to develop large den trees, and once developed some trees (oaks, sugar maple) can live for several hundred years (DeGraaf and Shigo 1985). Once den trees die and fall to the ground, the remnant hollow log may last 25 years, providing breeding habitat for redback salamanders and ringneck snakes.

#### 5.4.3.1.7 *Downed Woody Material*

**Management Objective:** DWSP will continue to maintain a range of sizes and types of downed woody material and retain or provide downed woody material in sites where it is lacking.

#### **Recommended Practices:**

- Leave snags in place if they must be felled during management operations.
- Avoid damaging existing downed woody material during harvesting, particularly large (>16" dbh) hollow logs and stumps.
- Leave, when possible, at least 4 logs of decay class 1 and 2 per acre; at least 2 of these logs should be >12" dbh and >6 feet long. Hollow butt sections of felled trees can be used. (See **Fig 20** above).
- Retain as many logs as possible of classes 3, 4, and 5. (See **Fig 20** above).
- On slopes, orient logs along contours and place against stumps when possible. In full overstory removals, leave slash on at least 10% of the site in scattered piles or rows.
- Do not add debris to streams and avoid disturbing woody material already in stream.

Downed woody material refers to slash, logs, large and small limbs, stumps, and upturned tree roots that accumulate on the ground either naturally or through forestry operations. Downed woody debris provides food, cover, and nursery habitat for a range of flora, fauna, and fungi. Downed woody material provides critical wildlife habitat and is used for nesting, shelter, drumming, sunning, as a source and place to store food, and as natural bridges. The specific value of downed woody debris depends on the physical distribution, amount, size, degree of decay, and orientation of debris relative to slope and exposure (Flatebo et al., 1999). Decaying logs also serve as nurse-trees for seedlings and colonization sites for fungi. Too much or too little downed woody material can be detrimental to wildlife. In general, it is best to retain or produce downed woody material that is distributed similarly to what might occur naturally as coarse woody debris in the given stand type (often random and clumped rather than evenly distributed).



Downed woody material.

Logs are generally considered to be the most valuable downed woody material because of their slow decay and longer persistence. Long logs >16" dbh are especially important wildlife habitat features. As logs age and decay their role as wildlife habitat shifts. Logs supported by branches provide shelter, feeding, and display sites for a variety of birds and mammals. As the log settles to the ground and continues to decompose it may be used by small mammals, snakes, toad, and salamanders for shelter, food, and travel. Large logs with hollow portions may be used as den sites by larger mammals.

#### **5.4.3.1.8 Woodland Raptor Nests**

**Management Objective:** DWSP will maintain suitable nesting sites for woodland raptors across the landscape over time and will avoid disturbing nesting pairs of raptors.

#### **Recommended Practices:**

- Contact Division's wildlife biologist when planning forest management activities in the vicinity of a bald eagle nest.
- Inspect mature white pine and hardwood trees for large stick nests when cruising timber. Do not cut trees, when possible, containing large stick nests and hardwoods with 3-pronged forks.
- Maintain an uncut buffer of at least 66 feet around active raptor nest trees and retain 65-85 percent canopy closure within 165 feet of large stick nests in closed-canopy forests.
- Maintain an uncut buffer of at least 66 feet around nest tree if an active raptor nest is located before or during a scheduled harvest operation; do not harvest within 330 feet of the nest during April-June.
- Harvesting schedules and buffer zones may be relaxed if an active raptor nest can be positively identified as belonging to a common or tolerant species (e.g., red-tailed or broad-winged hawk).
- Retain several super-canopy pines near the reservoir shoreline as potential future nest trees for bald eagles.
- Follow appropriate snag tree management guidelines.

Hawks, owls, falcons, and vultures are known as raptors. There are 19 species of raptors that breed in New England. Sixteen of the 19 species are known or potential breeders at the Quabbin (**Table 55**). Most raptors are predators that feed upon birds, mammals, fish, amphibians, insects, and snakes. While most raptors will eat a variety of animals, some species like the osprey have much narrower food requirements. Compared to other birds, raptors require relatively large home ranges (60->900 acres) in order to meet their food and nesting requirements. Raptor nests are widely dispersed across the landscape in a variety of habitats and forest conditions.

Some raptors will build a new nest each year within their territory, while other raptors will use the same nest for a number of years or claim the nest built by another species. Raptor nest trees must be large and strong enough to support nests ranging from 18" in diameter (broad-winged hawk) to over 3 feet (bald eagle, northern goshawk) (Flatebo et al., 1999). Large diameter broken stubs, closely spaced branches halfway up large white pines, and 3-pronged main forks of mature hardwoods are most frequently used by stick nest building raptors. By maintaining existing nests and identifying potentially good future nest trees, an area's raptor population can be maintained over a long period.

Many raptors nest early in the year. By February-March, most great-horned owls and some red-tailed hawks and barred owls are incubating eggs. Most other raptors will be incubating by May. Nesting raptors can be vulnerable to human disturbance. There is a wide range of tolerance depending on the species. Some intolerant species (bald eagles, goshawks) may abandon the nest during the early weeks of

incubation. Repeated flushing of the female from the nest may also subject the eggs to fatal chilling or the young to predation.

Identifying active nests is critical to ensuring their protection and establishing a buffer zone to minimize disturbance. The easiest, and unfortunately most infrequent, way to detect active nests is to see birds in or around the nest. However, active nests can be identified when no birds are visible by looking for the following indicators:

1. Prior to laying their eggs, some raptors 'decorate' the nest with fresh branches, usually from a conifer.
2. After hatching, whitewash (excrement), regurgitated pellets, and prey remains may be found on the ground near the nest tree.
3. Raptor nests can be distinguished from squirrel nests by their shape (squirrel nests are saucer-shaped) and lack of leaves (squirrel nests are made mostly of leaves).



Bald Eagle nest

**Table 55: Known and Potential Breeding Raptors at Quabbin**

Species	Breeding Status	Nest Site Selection
Turkey Vulture	Breeder	Rocky outcrops, ledges, cavities
Osprey	Potential Breeder <sup>1</sup>	Stick nests in trees, snags, poles
Bald Eagle <sup>2</sup>	Breeder	Stick nests in living trees
Northern Harrier <sup>2</sup>	Potential Breeder	On ground, over water
Sharp-shinned Hawk <sup>2</sup>	Potential Breeder	Stick nest on tree limb-usually conifers
Cooper's Hawk <sup>1</sup>	Potential Breeder	Stick nest (may use old crow nest) on horizontal branch in hardwood or conifer
Northern Goshawk	Breeder	Stick nest (used or new) in hardwood
Red-shouldered Hawk	Breeder	Stick nest (new) in tall tree
Broad-winged Hawk	Breeder	Stick nest in tall tree
Red-tailed Hawk	Breeder	Stick nest in oak/white pine
American Kestrel	Breeder	Cavity, nest box
Barn Owl <sup>2</sup>	Non-Breeder	Cavities, buildings, artificial
Screech Owl	Breeder	Cavities and woodpecker holes (Pileated/Flicker)
Great-horned Owl	Breeder	Cavities, old crow, hawk, or heron nests
Barred Owl	Breeder	Large natural cavities or old bird nests
Long-eared Owl <sup>2</sup>	Potential Breeder	Old crow/hawk nest or natural cavity
Saw-whet Owl	Breeder	Natural cavity or woodpecker hole
Short-eared Owl	Non-Breeder	Open fields, heath on Cape/Islands
Peregrine Falcon	Potential Breeder	Cliffs, tall buildings, urban areas

Source: adapted from DeGraaf and Rudis 1986

<sup>1</sup>Potential breeders are raptors not known to be currently breeding within the Quabbin watershed, but given the bird's range and habitat requirements it could breed there in the future.

<sup>2</sup>Listed with the Massachusetts Natural Heritage and Endangered Species Program as an endangered, threatened or special concern species.

#### **5.4.3.2 Considerations during Timber Marking, Harvesting, and Other Land Management Activities**

While careful planning and preparation can mitigate many of the potentially negative impacts on wildlife resources, some specific impacts or events cannot be discovered until operations begin in the field. Locations of active raptor nests, quality den and snag trees, and seeps may not be discovered until foresters begin marking individual trees in a lot. It is during these detailed lot inspections that some of the specific wildlife habitat management recommendations can be implemented. In addition, broader considerations such as timing of operations, harvesting techniques, record keeping, and other miscellaneous considerations should be addressed.

##### **5.4.3.2.1 Timing of Operations**

The timing of land management activities can have a dramatic impact on wildlife species. Some species (bald eagle, great-blue heron, and coyote) are extremely sensitive to human disturbance and may abandon or forgo breeding when repeatedly disturbed. Fortunately, some sensitive species can be easily identified or have known nesting sites. Great-blue herons nest in visible colonies, usually in dead snags over water. In addition, bald eagles build large stick nests that are easily seen and may be used for many years. However, for most other species their nest, burrow, or den is well hidden and would not be discovered until an operation had already begun. Luckily, most wildlife species tend to nest or den during the spring and early summer when land management activities are restricted.

When conflicts do arise, the following procedure will be followed:

1. Division personnel will notify the wildlife biologist when land management activities have clearly disrupted a rare or uncommon species' breeding efforts.
2. The Division wildlife biologist will assess/determine the nature of the nesting/denning activities, the species involved, stage of breeding (courtship, incubation, brooding), and initial response to the disturbance.
3. The Division will determine what options will be used to mitigate and avoid further disturbance during the remainder of the breeding season.

Land management activities conducted at other times of the year may unknowingly impact wildlife species, and efforts should be made to reduce these conflicts. Maintenance (mowing, burning, etc.) of fields and open areas should only be done in early spring (March/April) or after August 1 to avoid destroying nesting birds and mammals. No activity should occur in or near seeps during winter. If possible, winter activity should be avoided in and around identified wildlife wintering areas.

In some cases, activity during certain times of the year is preferred. Working around vernal pools is often best during winter when frozen/dry conditions minimize rutting and disrupting the forest floor. Further, logging during the fall and winter usually has minimal impact on most wildlife species and may actually benefit some animals by providing additional browse and cover.

Land management activities conducted at any time of the year have the potential to disrupt some wildlife species. However, this disruption is usually small in scale and scattered over the watershed. The benefits derived from actively managing the land outweigh the localized disruption. Because impacts cannot be avoided everywhere, the Division will:

- Continue to gather data on critical and sensitive wildlife and their habitats on the watershed.
- Assess the potential impacts of the timing and location of operations on a case-by-case basis to avoid impacting special concern species.
- When feasible, shift the timing or location of an operation to avoid these impacts.

#### **5.4.3.2.2 *Harvesting Techniques***

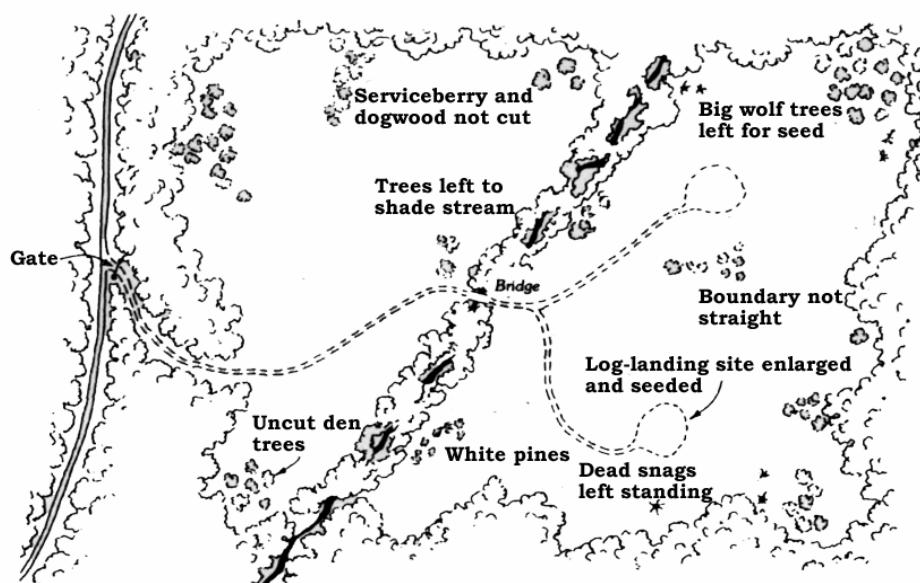
##### **5.4.3.2.2.1 *Group Selection Considerations***

When forestry operations use group selection to remove trees in openings 1 acre or greater in size, certain techniques and considerations can be used to enhance the area for wildlife. With proper planning, harvesting operations can be conducted while still maintaining snags, den trees, and mast producing trees within the opening (**Figure 21**; see Section 5.4.3.1). Note that while creating an irregular border on these openings increases edge habitat and will benefit those species that prefer edges, this same phenomena may increase predation on songbird nests and increase browsing on regeneration within the opening, among other undesirable effects (Hunter, 1990).

##### **5.4.3.2.2.2 *Logging and Skid Roads***

Access roads are used by the Division to remove wood, control fires, maintain watershed structures, and aid in navigation (see Section 5.3.6). Most Division roads within the watershed are narrow, grassy woods trails often referred to as logging roads. While roads are necessary to the Division, they can also act as barriers to animal movements and fragment the forest. The Division's use of uneven-aged management requires harvest operations to extend over a relatively large area and use comparatively short cutting cycles (20-30 years). As a result, an extensive network of roads are created and maintained, although careful planning can and should hold this network to a minimum.

**Figure 21: Forest Opening Planned with Wildlife Considerations**



The effect of forest roads on wildlife and biodiversity depends on the size, type and location of the road. The frequency with which a road is used and its proximity to other travel routes will also determine its impact. Roads effectively create an edge habitat that benefits some species, but has negative effects on species sensitive to disturbance or predators. Roads are often used by some wildlife species as travel lanes, but they may impede the movements of other species that require continuous vegetative cover. Roads may also fragment the forest and isolate individuals or populations.

Constructing and maintaining forest roads on Division property constitutes a relatively permanent change in the habitat structure of the area. Because traffic on Division roads, particularly at night, is minimal, there is little concern about direct mortality on wildlife populations. The more general concern is that a strip of dirt or gravel under an open canopy can serve as a physical or psychological barrier to animal movements (DeMaynadier and Hunter 2000). Studies have documented this barrier affect for small mammals and invertebrates (see DeMaynadier and Hunter 2000). In addition, DeMaynadier and Hunter (2000) recently documented the barrier affect of forest roads on salamanders.

When logging roads, skid trails, and landings are being planned, certain design features can be incorporated to minimize wildlife impacts:

- Logging roads/skid trails should avoid vigorous patches of shrubs.
- New logging roads should be minimized and existing roads should be upgraded instead if possible.
- Roads should be as narrow as possible, ideally one-lane with occasional turnouts.
- Circular routes should be avoided; a cul-de-sac design is better.
- Abandoned logging roads, skid trails, and landing sites should be seeded, when possible, with a grass-legume mixture.
- Road intersections should be angled to limit line of sight.

#### *5.4.3.2.2.3 Record Keeping*

Division Foresters, Rangers, and other natural resource managers spend a large amount of time walking, observing, and assessing lands within the Quabbin watershed. It is likely that they may observe

significant wildlife or important wildlife habitats. Because of the size of the watershed, these anecdotal observations are a critical source of biological information, and may be key to avoiding or mitigating potential wildlife impacts of future land management activities. These observations will be reported to the Division wildlife biologist so that records may be routinely maintained and updated.

#### *5.4.3.2.2.4 Miscellaneous Considerations*

The Division's silvicultural practices include cutting trees with weak crown forms that are more susceptible to damage. Some of these trees have wildlife value, and Division foresters should continue to leave some of these trees uncut. For example, trees growing on an angle ("hurricane-tipped") serve as travel routes for arboreal mammals from the ground to the forest canopy. In addition, older trees with large stocky limbs often have protected crotches that are used by nesting birds and mammals. These trees also typically have a high potential for cavity formation. While it is not necessary to maintain all examples of these trees, it is important to retain some during harvesting operations.

Particular combinations of trees species are also valuable to wildlife. Mature oak trees within hemlock or other conifer stands provide food resources within wildlife wintering areas. Small pockets of hemlock within hardwood stands can serve as significant wildlife cover. Both of these habitat conditions should receive special treatment when feasible.

#### ***5.4.3.2.3 Natural Heritage and Endangered Species Program Conservation Management Practices for Listed Wildlife Species (WCMPs)***

The Natural Heritage & Endangered Species Program (NHESP), in collaboration with DCR's Division of Water Supply Protection, DCR's Bureau of Forestry, and the Massachusetts Division of Fisheries and Wildlife's Forestry Program, is currently preparing wildlife conservation management practices (WCMP) documents for certain rare species that are listed and protected by the Massachusetts Endangered Species Act (MESA). These WCMP documents will provide information on the rare species' life history and habitat requirements and make scientifically-based recommendations on how to minimize potential adverse impacts of forestry activities. The goal of these recommendations is to protect rare species populations and maintain rare species habitats for long-term viability while maintaining the opportunity for the sustainable management of the state's forests.

The rare species information forming the basis of these documents has been gathered from a variety of sources. Information on specific rare species and their habitat requirements has been compiled from published scientific articles, books, unpublished reports, NHESP data, existing management guidelines from other states, and consultation with researchers who have first-hand experience with the species in Massachusetts.

The NHESP will use these recommendations in its review of specific Forest Cutting Plans. The existence of the WCMPs will improve the speed and consistency of the NHESP's reviews of Forest Cutting Plans and will make the outcome of the Cutting Plan reviews more predictable to the forestry community. These recommendations do not supersede any law, regulation, or official policy of this or any other agency. Rather, these guidelines are intended to complement existing regulatory review processes by providing up-to-date, scientifically-based management recommendations for forestry activities as they impact specific species.

Although the best available scientific information, researchers, and managers were consulted in preparing these documents, it is expected that new information will arise about the species' requirements and their response to habitat modifications. With the recognition that both forestry practices and rare species conservation require adaptive management it is acknowledged that the recommendations in these documents may need to be updated and revised in the future.

#### **5.4.4 Population or Impact Monitoring and Control Plans**

##### **5.4.4.1 Beaver**

###### **5.4.4.1.1 Aquatic Wildlife Pathogen Control Zone**

There is extensive research documenting the role of certain wildlife species in the transmission and amplification of water-borne pathogens. In order to address these concerns, the Division developed a control program to identify, remove, and study critical wildlife species from a defined area around the Chicopee Valley Aqueduct (CVA) Intake (for a complete description of the program see **Quabbin and Wachusett Reservoir Watersheds Aquatic Wildlife Pathogen Control Zones**, MDC 1999).

The program began in 1999, and it specifically targets beaver and muskrat populations living within the defined control zone (the cross-hatched area in **Figure 22**). Routine surveys are conducted within the zone, and any individuals of beaver or muskrat that are located are immediately removed. In addition, other activities are conducted to discourage animals from occupying the sites, including habitat modification and removal of lodges and dams. Control activities take place year-round through a special agreement with MassWildlife.

Since 2004, fecal samples have been collected from removed animals. Samples are tested for the presence of *Giardia spp.* and *Cryptosporidium spp.* Early results of this ongoing study indicate a relatively low rate of infection.

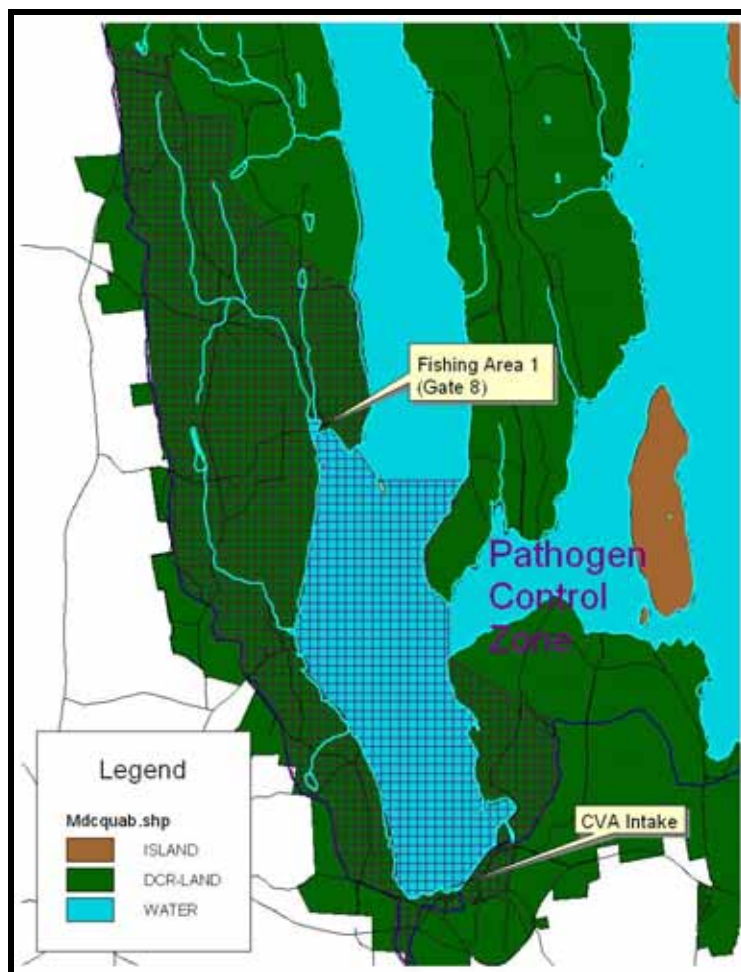
###### **5.4.4.1.2 Beaver Sites outside the Pathogen Control Zone**

Beaver can dramatically alter their surrounding habitat, which in turn can affect other wildlife species and humans. Beaver can cause localized damage to roads, culverts, and trees, although the habitat they create is seen as beneficial to a variety of wildlife species. Whether any one colony is seen as beneficial or detrimental depends on the resources affected. Division policy regarding beavers takes into account the variety of situations that may arise and applies solutions as needed to offer the best long-term remediation. Because beaver issues can become quite controversial, it is important to present the range of potential beaver impacts on riparian vegetation, water quality parameters, and the general ecology.

###### **5.4.4.1.2.1 Beaver Induced Alterations of Riparian Systems**

Beaver are one of the few wildlife species that have the ability to dramatically alter the surrounding habitat to their benefit. These habitat alterations can have potentially substantial impacts on the ecosystem. Changes in vegetation, biotic and abiotic features of the wetland, and impacts to other organisms may result. Riparian areas, particularly second- to fourth-order streams and adjacent low-lying areas are often colonized by beaver (Hammerson 1994). The presence or absence of beaver in an area or region can have a dramatic impact on the predominant vegetation. For example, in West Virginia, the widespread swamp forests common in the early 1900s were most likely the result of the eradication of beaver from the state by the early 1800s (Land and Weider, 1984 in Hammerson 1994). Most Division owned riparian areas are primarily forested with a variety of tree species. It is interesting to note that these forested wetlands in Massachusetts may also be an artifact of the beaver's eradication from the state by the late 1700s until their eventual return in 1928. As a result, changes to the riparian landscape caused by expanding beaver populations during the last 20-30 years may appear even more dramatic because they were absent from the ecosystem for many decades.

**Figure 22: Pathogen Control Zones at Quabbin**



The Division's primary interest is to preserve and protect water quality within the water supply reservoirs, and riparian areas are an important component to that protection. As a result, it is helpful to summarize the impacts of beaver on the biotic and abiotic components of riparian ecosystems in order to address potential negative impacts from their occupation of riparian areas. One of the most important factors related to changes in the environment is the structural integrity of beaver dams. Many of the components associated with beaver occupation of riparian zones are contingent on the longevity and stability of the dam itself. Dams that continually wash out may cause water quality problems associated with flooding and the sudden release of sediment and accumulated nutrients. It is usually dams on larger streams (above fourth-order) that are prone to washouts (Naiman et al., 1988). Many of the streams within the Quabbin watershed are first- to second-order streams, although there are larger streams (East and West branches of the Swift River) that are fourth- to fifth-order streams. Any beaver dams located on these higher order streams would be much more prone to wash-outs.

#### *5.4.4.1.2.2 Beaver Effects on Vegetation*

Beaver are strictly herbivores and have been described as choosy generalists (Novak, 1987). Beaver are also central place foragers because they return to their lodge or bank den after feeding (Naiman et al., 1988). This is a critical behavioral trait and, as a result, beaver foraging is restricted to a relatively narrow band of forest surrounding their pond (Johnston and Naiman, 1990). One study indicated that beaver fed preferentially on a few number of deciduous species and the number of stems cut declined sharply as distance increased from the pond (Donker and Fryxell, 1999). Barnes and Mallik (2001) found that 91%

of all beaver cut stems were within 20.1 m of the pond shoreline. Beaver will cut and consume a variety of woody vegetation in addition to feeding on aquatic vegetation during the spring and summer. Beaver do have a strong preference for certain species, particularly members of the aspen family.

When beaver colonize a new riparian area, several important events take place. Typically, a dam is constructed, and the raised water level kills trees within the flood zone. In addition, beaver cut down some trees along the shoreline. Although a substantial number of trees may be lost due to flooding, the wetland continues to be buffered by a forested habitat. The forested zone has been pushed back to where the high water level now occurs as opposed to lining the stream bank. Along the shoreline, some canopy trees are killed or toppled by beaver, allowing more light to reach the forest floor. Increased light, along with a decrease in competition for water and nutrients, will stimulate regeneration and a release of the forest understory (Johnston and Naiman, 1990). The light penetration may be sufficient to allow regeneration of shade-intolerant species (Donker and Fryxell, 1999). The amount of canopy being removed along the shoreline can vary. After 6 years of continuous occupation, one study site had a 43% reduction in basal area of stems >2 inches dbh (Johnston and Naiman, 1990). Other studies have indicated that perceived damage and actual damage to forest resources may be quite different. King et al., (1998) indicated that beaver in a wetland in the southern United States were having minimal effect on the forest. In this case it was determined that although tree damage was highly visible by casual observation, beaver were having little impact on tree survival.

In some cases where the overstory is primarily comprised of aspen (some western streams), a majority of the overstory may be removed, and the riparian area could go through a shrubby woody stage until non-browsed species grow and overtop the shrub layer. On the Quabbin watershed, aspen species are a relatively minor component to forested riparian areas. Most riparian areas consist of a diversity of species, making it less likely that all trees will be removed, although the shrubby component to the riparian area may become more dominant as some canopy trees are lost.

Beaver induced changes to vegetation along riparian zones can be quite dramatic when compared to conditions prior to beaver occupation. The primary result of these changes will be a shift in the species composition before and after beaver occupation. The shift may be undesirable if the species being lost are of high economic value (pine, oak, etc.). This is a particular problem in many southern states. In summary, the riparian wetland, although different, is still buffered by a forested habitat that may be more diverse and/or contain a larger shrubby component.

#### *5.4.4.1.2.3 Beaver Effects on Water Quality*

The Division manages beaver within the defined Aquatic Wildlife Pathogen Control Zone to control pathogen transmission (see Section 5.4.4.1.1). However, because beaver can alter the hydrologic regime of a riparian area, it is important to consider their impact with regards to general water quality parameters. As mentioned in Section 5.4.1.2.1.1, most streams within the Quabbin watershed are low-order (first-to-third) systems, and beaver dams constructed in these sites are most likely to exist in stable conditions for many years.

In many situations, beaver dams can transform a lotic system into a lentic habitat that may resemble a lake or pond\*. Some important changes associated with this transformation include increased water depth, elevation of the water table, an increase in the wetted surface area of the channel, and storage of precipitation, which is gradually released (Hammerson 1994). In addition, the storage of precipitation can reduce variability in the discharge regime of the stream (Hammerson 1994). Pondered riparian areas have an increase in aerobic respiration. Respiration is 16 times that found in a riffle (per linear meter of

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\* Lotic refers to aquatic communities found in running water. Lentic refers to aquatic communities found in standing water.

channel) (Hammerson 1994). In low-order streams there is a shift to anaerobic biogeochemical cycles in soil layers beneath the aerobic pond sediments (Hammerson 1994).

Ponded areas behind beaver dams reduce current velocity within the riparian area, which decreases erosion and stabilizes streambanks (Brayton 1984, Hammerson 1994). In some western states beaver were introduced into riparian ecosystems that had eroded streambanks and little vegetation along the shoreline (Brayton 1984). The result was a dramatic decrease in sediment transport downstream, streambank erosion was stabilized, and diversity of vegetation began to grow (Brayton 1984). In addition, by slowing down water velocity there is increased trapping of sediments behind beaver dams, and a resultant decrease in turbidity downstream (Brayton 1984, Hammerson 1994, Maret et al., 1987, Naiman et al., 1994, Naiman et al., 1988). Several studies have shown a substantial amount of sediment being collected behind beaver dams, ranging from 1.5-6 feet (Hammerson 1994, Meentemeyer and Butler 1999). Meentemeyer and Butler (1999) suggest that if beaver are eliminated from a landscape, basin sediment yields could increase dramatically. Having beaver present in a watershed in turn would help minimize sediment transport and stabilize stream banks (Meentemeyer and Butler 1999).

Changes in the chemical and physical properties of the stream occur when an area is dammed. Generally there is a reduction in Dissolved Oxygen (DO), Aluminum (Al), and Sulfate ( $\text{SO}_4^{2-}$ ), and an increase in pH, dissolved organic carbon (DOC), Iron (Fe), and Manganese (Mn) (Smith et al., 1991; Hammerson 1994). DO reduction was most likely the result of increased retention of organic matter and associated decomposition processes (Smith et al., 1991). By trapping large amounts of sediments and particulates, beaver ponds can also trap associated nutrients, including phosphorus (Maret et al., 1987). Phosphorus (P) is an important element in water supply reservoirs because it is often the limiting factor in the growth of aquatic plants and algae in reservoir systems (Lyons 1998). Other studies have shown that beaver activities may actually increase concentrations of P within the impoundment (Klotz 1998). However, in these studies it is clearly shown that increased concentrations of P only occur for short distances downstream of beaver ponds before equilibrium processes reduce the concentration (Klotz 1998).

One potential problem associated with beaver is the increase in DOC within the beaver pond. Though DOC does not directly affect drinking water quality parameters, it is a concern because of disinfection by-products. DOC in beaver ponds increases for several reasons. First, a large amount of wood is transferred into the stream channel, either directly through cutting or indirectly through flooding. In addition, more leaves are collected within a pond than in a stream channel. The carbon turnover rate for this material is less in a ponded area than in a stream with flowing water (Hammerson 1994). Margolis et al., (2001) found average DOC concentrations 10 m and 100 m downstream of a beaver impoundment were significantly higher than DOC concentrations upstream of a beaver pond or 1 m below the impoundment. Although increases in DOC are a potential concern, a recent study conducted at Quabbin suggested that biological processes and the sheer size of the reservoir prevented these elevated DOC levels from reaching the intake (Garvey 2000). In fact, this study suggests that algae are a much greater concern regarding disinfection by-products at reservoir intakes.

The overall effect of ponding riparian areas is the translocation of chemical elements from the inundated upland to the pond sediments or downstream. A portion of the chemical elements are transported downstream, while most are accumulated in the pond sediments and are available for vegetative growth if the pond drains and succession begins (Naiman et al., 1994).

#### *5.4.4.1.2.4 Ecological Impacts of Beaver*

There are ecological impacts as the beaver transforms the stream channel into a ponded area. The most immediate effect could be the potential loss of habitat for species either requiring large expanses of deciduous trees along a stream or those species living within the stream channel. Because a beaver dam influences only parts of a riparian area, it is unlikely that beaver activity would result in the disappearance

of species relying on wooded streams. In New York, experts agree that even after 30 years of expanding beaver populations, species or communities requiring wooded wetlands were probably not adversely affected on a regional or statewide level (Hammerson 1994).

There is often a good deal of concern regarding cold water fisheries and the impacts of beaver impoundments. It is likely that beaver both enhance and degrade suitable fish habitat. Hägglund and Sjöberg (1999) indicated that beaver enhance fish species diversity in Swedish streams. In addition, they speculate that beaver ponds serve as habitat for larger trout in small streams during drought periods. Snodgrass and Meffe (1998) indicated that in low-order streams, beaver had a positive effect on fish species richness. The maintenance of this effect however required the preservation of the dynamics of beaver pond creation and abandonment. The warming of stream water is often cited as a cause of concern regarding cold water fish habitat. A study done in Maryland and Pennsylvania reported that water temperatures were significantly greater downstream of beaver dams during the fall, spring, and summer (Margolis et al., 2001). McRae and Edwards (1994) indicated that large beaver impoundments would often warm downstream temperatures slightly, but they also served to dampen temperature fluctuations immediately downstream. In addition, when beaver dams were experimentally removed, there was no reduction in the difference between upstream and downstream temperatures. In some cases, dam removal increased the warming rate of the stream (McRae and Edwards 1994). It has been suggested that air temperature (not impoundments) is the single most important determinant of stream temperature in the absence of direct thermal inputs (McRae and Edwards 1994).

The impact on other organisms is less understood. Russell et al., (1999) reported that species richness and abundance of amphibians were not significantly different among old beaver ponds, new beaver ponds, and unimpounded streams. Reptiles did show a difference among sites. Richness and total abundance of reptiles was significantly higher at old beaver ponds (Russell et al., 1999). Another study found no significant differences in overall herpetofaunal abundance between uninterrupted streams and beaver ponds (Metts et al., 2001). However, significantly more salamanders were captured at uninterrupted streams and significantly more anurans, lizards, and turtles were captured at beaver ponds (Metts et al., 2001).

Invertebrate communities exhibit a strong ecological shift as running water taxa are replaced by pond taxa when streams are impounded. This results in an increase in the number of collectors and predators and a decrease in the number of shredders and scrapers (Naiman et al., 1988). While total density and biomass may be 2-5 times greater in ponds than riffles, the total number of species in ponds and streams appear to be similar (Naiman et al., 1988).

#### *5.4.4.1.2.5 Summary*

Beaver populations within the Quabbin watershed continue to fluctuate as beaver mortality rates remain low. As beaver continue to colonize riparian areas, it is important to recognize their role in hydrologic and ecological processes. A careful review of the literature would indicate that it is not the presence of beaver dams themselves but their persistence through time that has the biggest potential impact on water quality. The results of one study suggested that beaver ponds could improve water quality if they were located in the right locations; the authors deduced that it is the downstream channel that has the largest impact on water quality: “Our data illustrate the importance of location of beaver ponds along a stream in improving water quality. If water quality is to be maintained downstream from ponds and if nutrient export to a lake or reservoir is to be reduced, then the channel downstream from the pond complex must be stable or the pond complex must be located close to the lake or reservoir”(Maret et al., 1987). Most streams within the Quabbin watershed are low-order (first to third), and beaver dams constructed across these streams have the strong potential for long-term stability and persistence. On those sites with historically unstable beaver dams or on particularly “flashy” streams, beaver control will be addressed as described in section 5.4.4.1.3.

Some water quality parameters are changed or modified when beaver dam riparian areas. Generally, there is a reduction in DO, and an increase in DOC, pH, and Fe. Some studies have suggested that these changes may carry at least 100m downstream of an impoundment. Most evidence would suggest that beaver ponds (like most wetlands) have either no negative effect on water quality or have a filtering effect that improves water quality by decreasing erosion, trapping sediments, particulates, and nutrients. Changes to vegetation along the banks of beaver ponds results in a species shift away from species preferred by beaver or economically valuable deciduous trees to a larger proportion of woody shrubs and unpalatable or undesirable (by beaver) canopy trees. The more open canopy that results from beaver activity stimulates regeneration and increases habitat diversity.

Overall, there appear to be either no effects or positive effects on both faunal species richness and diversity when comparing ponds to unaltered riparian wetlands. There are still site-specific situations where beaver will need to be controlled as detailed in the next section. Outside these specific situations where damage is occurring, there does not appear to be a need for the Division to focus beaver control efforts on a watershed basis.

#### **5.4.4.1.3 Beaver Management Policy**

It is the Division's general policy to allow unrestricted beaver occupation. However, the following situations are examples where beaver activity may be discouraged, mitigated, or modified:

- Beaver activity that threatens rare or uncommon plant or animal communities.
- Beaver activity that precludes the use of necessary access roads needed for watershed maintenance, management, or protection.
- Beaver activity that threatens the proper functioning or structure of dams, culverts, and other parts of the water supply infrastructure.
- Beaver dams on unstable or flashy streams with a history of, or potential for, regular washouts.

The following procedure will be used to mitigate the damage when there is a conflict with a beaver colony. Division personnel encountering problem beaver sites should fill a *Beaver Damage Observation Form* and return it to the Division wildlife biologist and Quabbin/Ware River Regional Director. Upon review, the wildlife biologist and Regional Director will decide the most appropriate control activity for each site. Options available include: water level control devices, dam stabilization, culvert protection, or lethal removal. Site-specific control options will be chosen based on site conditions, history of the site, and type of damage occurring. The goal is to provide the most effective control possible that mitigates the problem. Appropriate permits will be obtained when necessary (e.g., removing a section of dam to install a flow control pipe).

Lethal removal will be a viable option, but will only be used if all of the following criteria for the site are met:

- Beaver are causing documented (observation, photographs, etc.) damage to DCR infrastructure (roads, culverts, bridges).
- Other, non-lethal means (water level control devices, fencing, etc.) would not be able to mitigate the problem because of limitations in access, maintenance, or effectiveness.
- DCR property being damaged is essential and cannot be temporarily abandoned.

- Lethal measures can be implemented within appropriate laws and guidelines and without threat to the safety of the public, domestic animals or other wildlife.

When lethal measures are to be used, the following procedure must be followed:

- The above criteria must be documented prior to action (using *Beaver Damage Observation Form*).
- Beaver will be removed through shooting (12 gauge shotgun), or live-trapping during the beaver trapping season using Hancock, Bailey or cage traps and then shooting.
- Two staff will be present at all time and will include one supervisor. The supervisor will be a Water System Storage Foreman II or higher. All staff participating will have a Firearms ID card. Any persons using live-traps must be properly trained.
- Every attempt will be made to retrieve beaver carcasses, and upon retrieval a fecal sample will be collected and then the animal will be buried at a suitable location.
- Personnel taking part in beaver control activities will take adequate precautions (washing hands/wearing rubber gloves) to prevent possible transmission of *Giardia* and *Cryptosporidium* and other pathogens.
- The supervisor in charge will document all actions and complete the proper *Beaver Removal Documentation Form*, of which copies will be sent to the Wildlife Biologist and Regional Director.

#### 5.4.4.2 Birds

##### 5.4.4.2.1 Gulls

Quabbin Reservoir provides a nighttime roosting site for a variable number of gulls throughout the year. In addition, a small number of gulls will use the reservoir during the day as a loafing and resting area. Herring, ring-billed, and great black-backed gulls are the most common species. Gull numbers begin to increase during the late summer and continue to increase throughout the fall. During winter, numbers can grow substantially and usually reach their peak when all other local bodies of water have frozen but Quabbin remains open. It is not unusual to have as many as 2,500 birds roosting each night. By spring and early summer, most gulls have left the area and returned to their breeding sites along the coast (herring and great black-back) or to interior nesting lakes (ring-billed).

Roosting gulls typically leave the reservoir soon after sunrise and disperse to spend the day feeding at landfills, agricultural areas, large open fields, or at various shopping malls and parking lots. By late afternoon, gulls begin returning to the reservoir to roost for the night.

The Division has been monitoring gull populations at Quabbin since 1990. Gull populations and water quality parameters were studied in the early 1990s. Water quality sampling analysis determined that roosting gulls were responsible for an associated increase in fecal coliform counts. In response to this information, the Division initiated a gull harassment program in 1992. The program has been conducted yearly since and uses a combination of pyrotechnics and boats to harass and move birds away from the CVA. Harassment activities typically begin by October each year. Up to 3 boats are deployed each night to chase and harass gulls that are present within the gull harassment zone (**Figure 4**). Boats are on the water from late afternoon until after sunset. The program is administered by Environmental Quality staff

within the Quabbin section. The labor staff is responsible for operating the boats and firing the pyrotechnics.

**Figure 4: Quabbin Reservoir Gull-free Zone**



Control efforts during the active harassment period of the program are conducted 7 days/week until the reservoir freezes or birds disperse in the spring. When ice or weather prevents boats from being deployed, harassment occurs from strategically placed personnel on shore.

In addition to the gull harassment program, the Division has participated in efforts to control gulls at landfills. In 1998, the Department of Environmental Protection instituted regulations that required all municipal solid waste landfills to harass and discourage gulls from loafing and feeding at their sites. New landfills must submit a written gull harassment program prior to receiving their operating permit. In conjunction with these regulations, Division staff has assisted landfills in developing harassment plans and also aided landfills in actively harassing gulls.

Activities related to the gull harassment program that will take place during the next 10 years include:

- Make weekly observations of gulls roosting on the reservoir to determine numbers of birds, species distribution, flight paths, and behavior.
- Continue to monitor landfills to assess the effectiveness of harassment programs.
- Continue to investigate and document alternative sources of food for regional gulls, including agricultural areas, composting sites, and wastewater treatment facilities.
- Develop, when and where appropriate, new methods or techniques of harassing or discouraging gulls from critical areas of the reservoir.
- Initiate a comprehensive study of gull movements and biology using satellite telemetry.

#### **5.4.4.2.2 Geese**

Resident Canada geese are present at Quabbin Reservoir year round; they will leave the area when the reservoir freezes. In addition, during the fall and winter, migratory geese will also utilize the reservoir. While geese are much fewer in numbers than gulls, they still represent a priority management species and are actively harassed during the bird harassment program.

Since 1999 the Division has conducted a resident goose population control program at Quabbin Reservoir. Each spring efforts are made to locate geese nesting on the reservoir. Once identified, eggs in each nest are treated to prevent hatching. The long-term goal of this program is the gradual reduction in the resident adult goose population. In addition to efforts to locate and treat nests close to the CVA, (Table 56), this program now includes an extensive search of all reservoir islands.

**Table 56: Number of Canada Goose Nests and Eggs Treated 1999 -2007, to Prevent Hatching**

<b>Year</b>	<b># Nests</b>	<b># Eggs Treated</b>
1999	8	37
2000	10	37
2001	9	41
2002	7	36
2003	7	36
2004	7	34
2005	3	11
2006	9	43
2007	6	34

#### 5.4.4.2.3 Other Waterfowl

A variety of other waterfowl utilize Quabbin Reservoir at various times during the year. During the spring and summer, there is a relatively small number of resident mallard ducks that nest on islands. During the fall and winter, the number of waterfowl can increase substantially as migrating birds use Quabbin as a rest stop. Ring-necked ducks, common mergansers, common goldeneyes, and other species can all be found on the reservoir during the fall and winter. All species of waterfowl are included in the harassment efforts if they are located within the bird harassment zone.

#### 5.4.4.3 Burrowing Animals

The burrowing activity of certain wildlife species such as woodchucks, moles, and voles can cause damage to the integrity of earthen dams, dikes, and other watershed structures. Woodchucks have been a recurring problem along Winsor Dam in the past few years. Both lethal methods and live-trapping have been used to remove these problem animals. DWSP is working to develop long-term management techniques to discourage reoccupation.

#### 5.4.4.4 White-Tailed Deer

White-tailed deer populations are increasing in most of the northeast. There is growing concern about these increasing populations and their impact on natural resources (Healy 1997a, Healy 1997b, Alverson and Walker 1999, McShea and Rappole 1997). Deer populations within Massachusetts are increasing in the central and eastern part of the state (MassWildlife, pers. comm.). White-tailed deer can thrive in suburban environments where there is abundant food, few predators, and enough wooded areas to provide cover. Coupled with expanding deer populations is increased fragmentation of the landscape that can isolate these wooded reserves and in many cases prevent people from effectively hunting white-tailed deer populations. Even in areas where hunting is feasible, there is growing concern that both hunter interest and hunter recruitment is declining. In many situations, these circumstances can lead to overabundant deer densities.



Overabundant deer populations can influence and affect the abundance of woody species (Walker and Alverson 1997). In addition, intensive deer browse may cause problems in regenerating particular species such as oak. When deer populations are protected for many years and sustained at high densities, forest structure may be altered completely, resulting in park-like stands with grass or ferns dominating the understory (Walker and Alverson 1997). Situations like this were documented on the Quabbin Reservation and in the Alleghany National Forest in northwest Pennsylvania (Walker and Alverson 1997). In response to growing concerns about the lack of forest regeneration and the absence of an understory layer within large portions of Quabbin Reservation, the area was opened to limited, controlled public deer hunting in 1991. Hunting has been conducted on the reservation each year since.

The controlled hunts constituted only one component of a comprehensive 1991 White-tailed Deer Impact Management Plan for the reservation that also included the use of electrified fencing and various changes in the Division's land management program. That plan called for six years of controlled hunting, followed by a major review and re-evaluation of the program. That review was conducted in the spring of 1997 when two reports (*Quabbin Regeneration: Summary Report 1988-97* and *Quabbin Reservation White-tailed Deer Impact Management Program: Results and Evaluation 1991-1996*) were issued by the Division. Also at that time, recommendations for the next phase of the program were issued in the document *Quabbin Reservation White-tailed Deer Impact Management Program: Summary Report and Proposal 1997*. Those recommendations called for a continuation of the controlled hunting program with several changes proposed to make the program more efficient.

The driving force behind the deer reduction program has always been to reduce the impacts of deer browsing to a level that allows and promotes the development of a healthy, resilient, diverse forest that can adequately and continuously protect water quality. Major components of the deer population reduction program were to: 1.) Reduce population densities; and 2.) Maintain those densities at a level that allows for the continued growth and regeneration of forest tree species.

After several years of controlled hunts, substantial reductions in deer population densities were achieved in all hunt areas, and the Division has been in the maintenance phase of its program for several years. The maintenance phase of the program is essential for maintaining relatively stable deer population levels and eliminating potentially large swings in deer densities that could occur if hunting were stopped for an extended period of time. In the absence of regular hunting mortality, deer populations at lower densities that have little natural mortality and an increasing food supply would expand and could jeopardize the forest regeneration progress made to date. In 2000, a five-year plan was developed that outlined proposed activities for the next five years. In 2004, a second 5-year plan was written, and it outlined the program's goals and plans through 2009 (Clark 2004).

Since 1991, Quabbin deer populations have been decreased substantially through the annual managed hunts, and the forest has responded tremendously. Regeneration surveys conducted during 2004 indicate that the number of tree stems/acre has increased from 910 in 1989 to 4,532 in 2004 (a 400% increase). Tree species diversity also continues to increase, and although white pine and black birch dominate the understory, more maple, oak, and hemlock trees are present.

Deer hunting on Quabbin Reservation is limited to a 4-day managed hunt, with access strictly controlled through a check-in/check-out procedure. Participating hunters are required to attend an orientation session every 6 years and follow specific rules and regulations to ensure hunter safety and protect water quality. Since 1991, over 4,000 deer have been harvested from Quabbin Reservation by approximately 19,000 hunters (**Table 57**). Since 1991, several administrative changes have been made to the hunt including allowing car scouting prior to the hunt, instituting a 5-block rotation, and defining antlerless deer killed at Quabbin as "bonus" (not counting towards the state-wide bag limits).

**Table 57: Deer Harvest and Hunter Success Rate, 1991 to 2005**

YEAR	TOTAL DEER	% FEMALE	% MALE	% A/L <sup>1</sup>	DEER/Mi <sup>2</sup> (killed)	# HUNTERS	HUNTER SUCCESS <sup>2</sup>	Mi <sup>2</sup> HUNTED
1991	575	60.3	39.7	71.8	40.9	855	67.3	14.1
1992	724	54.0	46.0	60.5	21.7	1971	36.7	33.4
1993	474	62.0	38.0	67.1	9.5	2168	21.9	49.7
1994	673	59.9	40.1	68.9	10.7	2118	31.6	63.1
1995	284	64.8	35.2	74.3	4.7	1508	18.8	60.9
1996	129	58.1	41.9	67.4	2.0	1213	10.6	63.1
1997	293	62.1	37.9	73.4	4.8	1207	24.3	63.1
1998	123	57.7	42.3	65.9	2.3	1099	11.2	55.8
1999	112	39.3	60.7	51.8	1.8	1192	9.4	63.1
2000	106	47.2	52.8	55.7	1.7	818	13.0	49.1
2001	101	51.5	48.5	58.4	1.9	855	11.8	52.0
2002	153	48.4	51.6	64.1	3.0	967	15.8	50.2
2003	306	69.0	31.0	83.7	6.9	938	32.6	44.2
2004	167	47.9	52.1	58.7	3.0	1259	13.3	55.8
2005	117	53.0	47.0	65.0	1.8	1071	10.9	49.0
<b>Total</b>	<b>4337</b>	<b>55.7</b>	<b>44.3</b>	<b>65.8</b>		<b>19,239</b>	<b>21.9</b>	<b>-</b>

<sup>1</sup> A/L: antlerless; females and young males with antlers less than 3 inches long.

<sup>2</sup> Hunter success is the number of deer taken per 100 hunters. Some hunters took more than one deer, so these figures slightly overestimate the proportion of successful hunters

#### **5.4.4.5 Moose**

##### **5.4.4.5.1 General**

Moose are North America's largest wild animal. An average adult moose weighs around 1,000 pounds and stands 6 feet at the shoulder. Moose and their ancestors originated in Siberia and made their way to North America across the Bering land bridge. At the time of European settlement, moose were distributed from Alaska, across Canada into the northern United States from North Dakota east to Pennsylvania and all of New England, including Massachusetts. Moose also extended down the Rocky Mountains in the West. Temperature was probably the limiting factor in the southern distribution of moose in North America. Winter stress typically occurs when temperatures exceed 23°F and summer stress when temperatures are >59°F (Franzmann and Schwartz 1997).



Moose were extirpated from Massachusetts by the early to mid-1800s (Peek and Morris 1998, Veccillio et al., 1993). A small number of moose escaped from a game preserve in Berkshire County around 1911 and may have persisted for several years (Veccillio et al., 1993). Most sightings during the next 50 years were probably northern vagrants. Since the late 1980s, the number of moose sightings has increased greatly (Peek and Morris 1998). In 1998, the state's moose population was estimated as at least 75 animals including cows with calves (Peek and Morris 1998). Current estimates of moose populations in Massachusetts are around 700 animals (MassWildlife pers. Comm.). Reasons for the increase in moose populations include the absence of predators, reversion of farms to forested areas, legal protection, increased wetlands from expanding beaver populations, and larger forest openings (Franzmann and Schwartz 1997).

Moose populations continue to expand in Massachusetts. Division land within the Quabbin watershed probably functions as a core habitat for moose populations given its large size and diversity of habitats. Moose populations in the state suffer relatively little natural or human caused mortality. Black bears are the only potential predator of moose and are limited to killing young calves. There are approximately 2000 black bears in Massachusetts, and most of them are located west of the Connecticut River. As a result, current bear populations are not capable of limiting moose populations. The main source of moose mortality is most likely from interactions with people. In 1997, 12 moose were killed on roads, 4 nuisance animals were destroyed, and 4 were immobilized and relocated (Peek and Morris 1998). It is likely that moose/vehicle collisions will continue to rise as moose populations expand. Because moose/car collisions are extremely dangerous for both humans and moose it has been suggested that moose are incompatible with an urbanized state such as Massachusetts, and the public's tolerance of moose is limited (Peek and Morris 1998, Veccillio et al., 1993).

##### **5.4.4.5.2 Moose and Vegetation**

Moose are primarily browsers and feed on the leaves, buds, and twigs of a variety of tree and shrub species. An adult moose can consume 40-60 pounds of browse daily (Snyder 2001). During the summer, moose spend time in lakes and ponds feeding on aquatic plants.

A good deal of work has been done assessing the impact of moose on boreal forest ecosystems (Danell et al., 1991, Edenius 1994, Angelstam et al., 2000, Connor et al., 2000, McLaren et al., 2000, Brandner et al., 1990, McInnes et al., 1992). There exists little if any information on the impact of moose in the southern portion of their range. While boreal ecosystems are relatively simple in terms of species diversity and structure, forests in Massachusetts are much more complex in both composition and processes. While information regarding moose in boreal ecosystems is important and insightful, it does not necessarily represent moose in mixed hardwood/softwood forests.

In Europe, moose were shown to have negative impacts on the quantity and quality of Scots pine (Angelstam et al., 2000). Moose density was found to be the contributing factor affecting the amount of moose related damage (Angelstam et al., 2000). A study in a Newfoundland park suggested that moose have changed species composition and influenced forest succession (Conner et al., 2000). Hunting has been prohibited in the park since 1974, and natural predation by black bears has not had an impact on the moose population (Conner et al., 2000). Several studies have examined the interaction of moose and Balsam fir, a preferred winter food of moose. In order to successfully regenerate Balsam fir in Newfoundland, McLaren et al., (2000) had to maintain high hunter harvest until trees were >3m in height. McLaren et al., (2000) concluded that since wolves were extirpated from Newfoundland, hunting has been the only option to reduce moose populations. McInnes et al., (1992) concluded that moose in the boreal forests of Michigan prevented saplings of preferred species from growing into the canopy. Further, it appeared that browsing by moose influenced the long-term structure and dynamics of the boreal forest ecosystem (McInnes et al., 1992).

Compared to the relatively simple ecosystem of the boreal forest, Massachusetts's forests are comprised of a diversity of hardwood and softwood species. The relative impact of moose on any particular species is unknown. However, there is substantial evidence linking overabundant deer populations in hardwood forests with negative environmental impacts (McShea et al., 1997). If moose populations continue to expand, the potential exists for moose to impact forest ecosystem structure and function. Localized browsing damage has already anecdotally been noted, particularly during winter weather when moose mobility becomes hampered and browse pressure becomes locally intense.

#### **5.4.4.5.3 Monitoring Moose Populations**

Because moose populations are expanding in Massachusetts and little is known about the potential impacts of moose on forest ecosystems, it is important to monitor moose populations over time to gather as much information as possible. The Division has taken an active role in a variety of moose research or moose related topics, including:

1. In April 2002, the Division began a moose monitoring program on the Ware River watershed (see **Estimating Relative Abundance of Moose on MDC Property: Results of the 2002 Ware River Pilot Project** report). Monitoring has continued yearly since 2002, and will continue into the future. The same monitoring program was initiated at Quabbin in 2003 on the Prescott Peninsula. However, staff shortages have prevented the study from being done since. Efforts will be made to restart the study during 2008.
2. The Division contributed \$20,000 to funding a cooperative study of moose in Massachusetts. The study, being conducted by UMass and the USGS Massachusetts Cooperative Fish & Wildlife Research Unit, has several moose tagged with GPS collars to closely follow their movements.
3. An aerial infra-red survey of Quabbin Reservation was conducted during the spring of 2007 to identify deer and moose. The survey produced a known minimum number of animals during one point in time. While initial results were encouraging, time constraints prevented the contractor from adequately completing the survey. A new survey is scheduled for fall 2007.
4. Division staff have provided testimony at Senate sub-committee meetings discussing the potential impacts of moose on the landscape and encouraging legislators to modify existing laws to allow moose to become a regulated game species.
5. During the 2006 Quabbin deer hunt, hunters were given moose survey cards to report sightings. Hunters who saw moose during the hunt filled out the survey card and reported their sightings to Division biologists to record on a topographic map. Sightings were used to estimate minimum population estimates. Surveys will continue during future Quabbin hunts.